Value Potential of Digital Twins and Digital Threads

November 6 2025 – PLM Road Map & PDT Europe

PLM Road Map™ & PDT Europe 2025

PLM's Integral Role in Digital Transformation From Strategy to Execution
Elevating PLM to an Enterprise Business Solution,
the PLM Professional's Road Map to Success
5 & 6 November

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Value Potential of Digital Twins and Digital Threads

Results of Industry Research

Robert Rencher, Sr. Process Engineer, The Boeing Company
Project Leader, AD PAG Digital Twin-Digital Thread Project Team

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Presenter's Profile

Dr. Robert J. Rencher, Sr. Process Engineer, The Boeing Company

- As a Sr. Process Engineer, Robert provides leadership in facilitating a common understanding, strategic roadmap, and functional utilization of digital twins and digital threads standards across Boeing and the aerospace industry. Robert represents Boeing's strategic digital twin/digital tread interests to several aerospace and defense industry standards bodies (AIA, ISO, SAE, OMG, and A&D PLM Action Group)
- Robert has over 40 years of experience in designing successful solutions for complex information technology challenges. He joined Boeing in 1987 as a Systems Analyst. Robert holds a BS degree in Operations Research, an MBA in Information Technology, and a Ph.D. in Information Technology.
- As an avid inventor, Robert has 14 U.S. patents, numerous published technical papers at international technical conferences. Robert's personal pursuits include real estate development, gardening, and community service. robert.j.rencher@boeing.com / https://www.linkedin.com/in/robertjrencher/

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Agenda

- Introduction
- Benchmark Plan
- Use Cases
- Use Case Demonstrations
- Conclusions
- Q & A

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Aerospace & Defense PLM Action Group

Founded in February 2014

Mission

An association of aerospace & defense companies within CIMdata's globally recognized PLM Community Program, which functions as a ***PLM advocacy group*** to . . .

Members

AIRBUS, BOEING, Bombardier, EATON, GE Aerospace, GKN AEROSPACE, Gulfstream, Hondajet, MOOG, ROLLS ROYCE, RTX (COLLINS AEROSPACE, PRATT & WHITNEY, RAYTHEON), SAFRAN, SPIRIT AEROSYSTEMS

Project Workstreams

- PLM Technology Obsolescence Management
- Global Collaboration
- Model-based Definition (MBD)
- Multiple View Bill of Material (Multi-view BoM)
- Model-Based Systems Engineering (MBSE)
- Interoperability Standards
- Digital Twin/Digital Thread (Dtw-Dth)

Collaborative Research with Solution Providers

- Digital Thread
- Model-based Systems Engineering

Website: www.ad-pag.com

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AD PAG Digital Twin-Digital Thread Project

Approach

- Agile methods employed to publish at the speed of consensus
- Release five position papers addressing varying aspects of Digital Twin / Digital Thread concepts and capabilities related to the aerospace industry
  - Phase 1: Digital Twin/Thread – Research & Scoping
  - Phase 2: Digital Twin/Thread Position Paper
  - Phase 3: Digital Twin/Thread Business Architecture / Methodologies paper
  - Phase 4: Digital Twin/Thread Comparative Analysis of Industry Standards paper
  - Phase 5: Value proposition of the Digital Twin/Digital Thread to the A&D industry
  - Phase 6: Forward-looking Digital Twin/Thread Strategy and Roadmap
  - Phase 7: Project Consolidation
- Scope the project to deliver value early and iterate
  - Scope to the A&D industry
  - Time box the effort to approximately 36 months

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Benchmark Plan

Objectives

Primary

- A broad assessment of the capabilities of commercially available digital twin/digital thread solution offerings, including software and services
- Mutual education and alignment of thought leaders from industry and leading solution providers on digital twin/digital thread use cases and solution strategies
- Advancement of industry's awareness and understanding of the current practical value potential of digital twin/digital thread investment

Secondary

- Content that will be useful for future engagement with standards organizations for enrichment of standards to address digital twin-digital thread requirements

Provide a generalized assessment of the state of the industry and <u>not</u> a competitive comparison between the benchmarked solutions

Benchmark Plan

Execution strategy

Tailored Approach

- Partner with other industry organizations
- Invite participation of a broad community of solution providers
- Capitalize on existing use case solutions
  - Natural selection of what is possible today from the virtually unlimited set of possibilities
  - Dramatically reduces the effort required to prepare the benchmark demonstrations

Use Case Selection and Preparation

- Compare the participating solution provider's use case library with the AD PAG's use case library
- Default demonstration environment is that of the participating solution provider

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Benchmark Plan

Execution strategy

Recognizing the breadth and the state of maturity of the topic, the benchmark inquiry was not focused solely on "measuring how well it is done" but more broadly on "understanding

- *how* it is done,
- *what* is real today, and
- *where* it is going"

Solution Provider Engagement

Part 1

1. Welcome and Meeting Objectives
2. Solution Strategy
3. Implementation Approach

Part 2

4. Use Case Demonstrations

** Agenda Item 4 to be repeated for each use case **

Part 3

5. Solution Provider's View to the Future
6. A&D industry's view of future
7. Wrap-Up

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Benchmark Plan

Industry partners and participating solution providers

Industry Organization Partners

AIAA, Digital Engineering Integration Committee

OMG, Digital Twin Consortium, A&D sub-team

Prostep iViP, Collaborative Digital Twin (CDT) working group

SAE International, G-31 Digital Communications Committee

All contributed use cases from their internal project libraries

Contributed 39 of the 92 use cases in the project Use Case Catalog

Participating Solution Providers

Ansys part of SYNOPSYS

Capgemini

Cortona3D

eQ Technologic

HEXAGON

Infosys

PROSTEP integrate the future

Contributed 38 use cases

Demonstrated 9 digital twin and 19 digital thread use cases from the project Use Case Catalog

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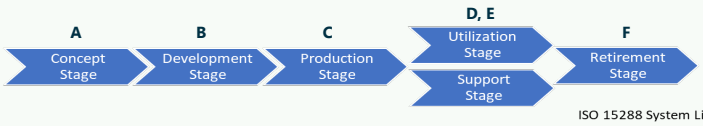
Demonstration Use Cases

9 Digital Twin Use Cases – Spanning the lifecycle



ISO 15288 System Lifecycle

Digital Twin Use Case	Lifecycle Stage A	B	C	D	E	F
Material Modelling Twins As-Built Part / Component Twins for Quality	■	■				
Understanding the Performance of a Solar Aircraft Using Digital Twin	■	■	■	■	■	■
OpenPDM - Bi-directional CAD integration between different vendor PLM's	■	■	■			
Virtual Commissioning Automotive Demonstrator for Body-in-White Assembly	■	■	■	■	■	
OpenDXM GlobalX - Collaboration with external partners	■	■				

Digital Twin Use Case	Lifecycle Stage A	B	C	D	E	F
Model-Based Systems Engineering (MBSE) and Digital Twin Realization of a Drone	■	■	■	■		
Echo Digital Twin Application Development Framework – YVR & Pearson	■	■	■	■		
Battery Package Assembly Demonstrator for Creation of an Assembly Concept	■	■	■	■	■	
Modelling of Complex Multi-Fidelity, Multi-Domain, System-of-Systems (SoS) Mission	■	■	■			

Key: ■ Create ■ Consume

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Demonstration Use Cases

19 Digital Thread Use Cases – Spanning the lifecycle

Digital Thread Use Case	Lifecycle Stage A	B	C	D	E	F
Design of Axial Compressor for Gas Turbine Engine	■					
Collaborative System Engineering	■	■				
Cross System/Domain Impact Analysis	■	■				
Cameo PLM Integration	■	■				
Cross-Discipline Engineering	■	■				
Model-Based Systems Engineering and Associated Topics	■	■				
End2End Additive Manufacturing	■	■	■			
Virtual Quality Assurance	■	■	■			
Solution Architecture Model	■	■	■			
Integrated Enterprise Configuration Lifecycle Management and Baselining	■	■	■	■	■	

Digital Thread Use Case	Lifecycle Stage A	B	C	D	E	F
Digital Engineering Certification Solution (DECS)	■	■	■	■	■	
A Day in the Life of Data Workers with an Automated Digital Thread	■	■	■	■	■	■
Long-Term Data Archival and Retrieval	■	■	■	■	■	■
Generation, Configuration Management, and Impact Assessment of the Digital	■	■	■	■	■	■
Virtual Assembly		■	■			
Production and Support		■	■	■		
Concession Management		■	■	■	■	
Technical Documentation in the Digital Thread			■	■	■	
Interactive Production and Maintenance					■	

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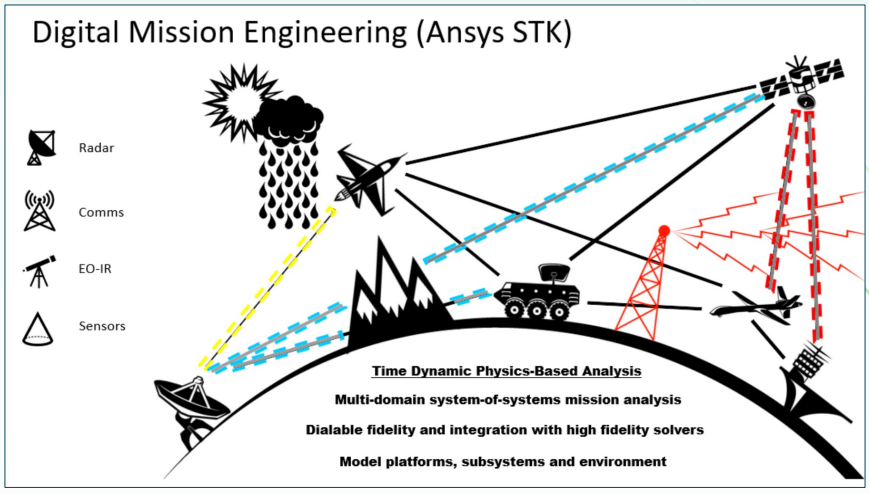
Use Case Spotlight

Modeling Complex Multi-Fidelity, Multi-Domain, System-of-Systems Mission Scenarios

Ansys part of SYNOPSYS



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Use Case Spotlight

Modeling Complex Multi-Fidelity, Multi-Domain, System-of-Systems Mission Scenarios

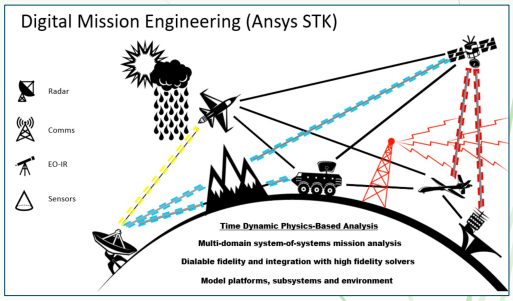
Ansys part of SYNOPSYS

Use Case Objective

Demonstrate modeling of complex, multi-domain system-of-systems mission scenarios, highlighting simulation depth, interoperability, and architecture scalability.

Business Context

Demonstrated digital mission engineering for aerospace and defense applications using what-if scenarios, integrating NI hardware-in-the-loop.



Key Highlights:

- Integration across systems
- Visualization & traceability
- Open data architecture
- APIs for extensibility
- Validated physics-based metrics
- Analytics and AI support
- Ease of deployment
- Multi-fidelity models

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Use Case Spotlight

Echo Digital Twin Application Development Framework – YVR

Capgemini

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Use Case Spotlight

Echo Digital Twin Application Development Framework – YVR

Capgemini

Use Case Objective

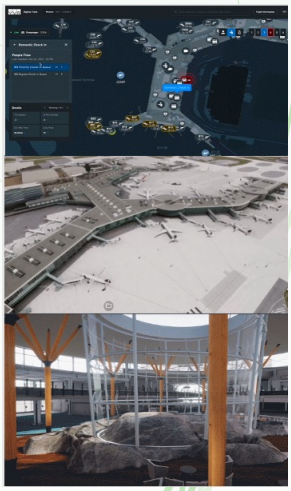
Establish a comprehensive digital twin that connects to Vancouver Airport's technology ecosystem to deliver real-time situational awareness and simulation capabilities.

Business Context

Vancouver Airport utilized Unity's real-time 3D engine and Capgemini's engineering capabilities to model all aspects of the airport from airside to terminal, integration with 3rd party systems and live data feeds.

Key Highlights

- Comprehensive modeling of airport systems and subsystems
- Better understanding of emissions data at the aircraft / vehicle level
- Strong adaptability, supporting multiple operational scenarios
- Over 700 active employees utilizing the desktop or mobile modules
- Navigate construction, weather disruptions and high demand



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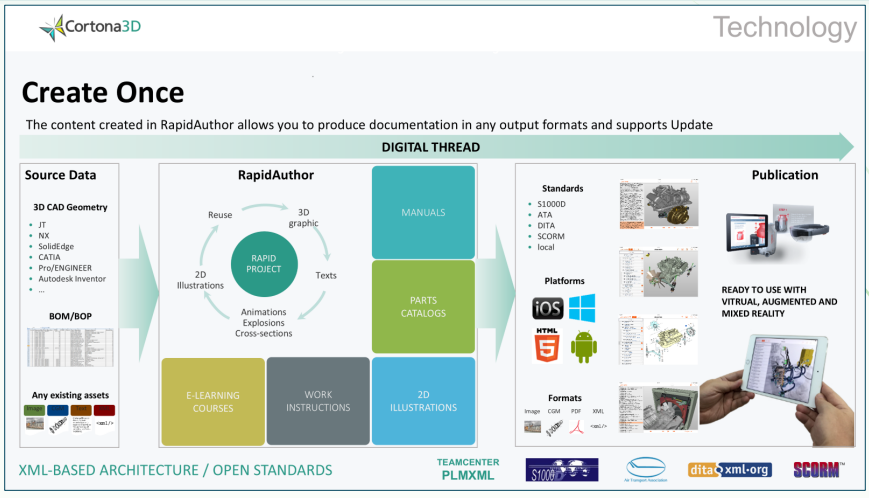
Use Case Spotlight

Technical Documentation in the Digital Thread

Cortona3D



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Use Case Spotlight

Technical Documentation in the Digital Thread

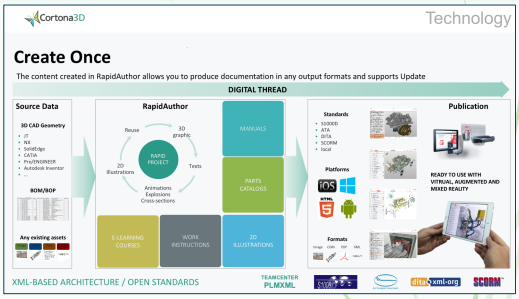
Cortona3D

Use Case Objective

Demonstrate automation in creating and maintaining technical documentation directly from PLM data, enabling streamlined publication processes and downstream digital thread alignment.

Business Context

Focused on semi-automated document generation from CAD, Bill of Materials (BoM) and Bill of Process (BoP) data, integrated within Siemens Teamcenter to enhance efficiency and accuracy in authoring and updates.



Key Highlights

- Automated generation and update of documents from PLM
- Tight integration with Siemens Teamcenter and Bill of Process (BoP)
- Comprehensive, user-friendly workflows

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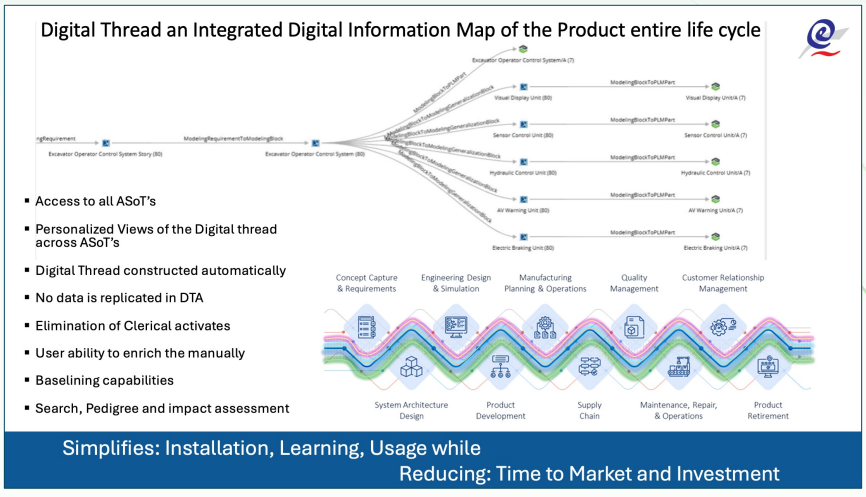
Use Case Spotlight

Generation, Configuration Management, and Impact Assessment of the Digital Thread

eQ Technologic



- Access to all ASoT's
- Personalized Views of the Digital thread across ASoT's
- Digital Thread constructed automatically
- No data is replicated in DTA
- Elimination of Clerical activates
- User ability to enrich the manually
- Baselining capabilities
- Search, Pedigree and impact assessment

Simplifies: Installation, Learning, Usage while Reducing: Time to Market and Investment

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Use Case Spotlight

Generation, Configuration Management, and Impact Assessment of the Digital Thread

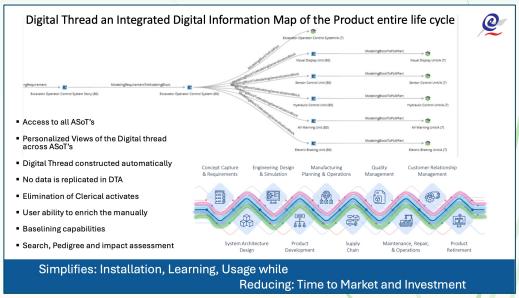
eQ Technologic

Use Case Objective

Demonstrate generation, configuration, and impact assessment of a digital thread, introducing related concepts such as digital fabric and digital stitch, while enabling secure multi-platform data connectivity.

Business Context

Ability to connect heterogeneous systems through governed data relationships, role-based visibility, and visual impact analysis, highlighting governance and flexibility in cross-platform digital threads.



Key Highlights

- Integrated view of digital thread, digital fabric, and digital stitch concepts
- Secure data connectivity between multiple systems, maintaining access controls
- Governance focus: highlighted need for clear ownership and control policies

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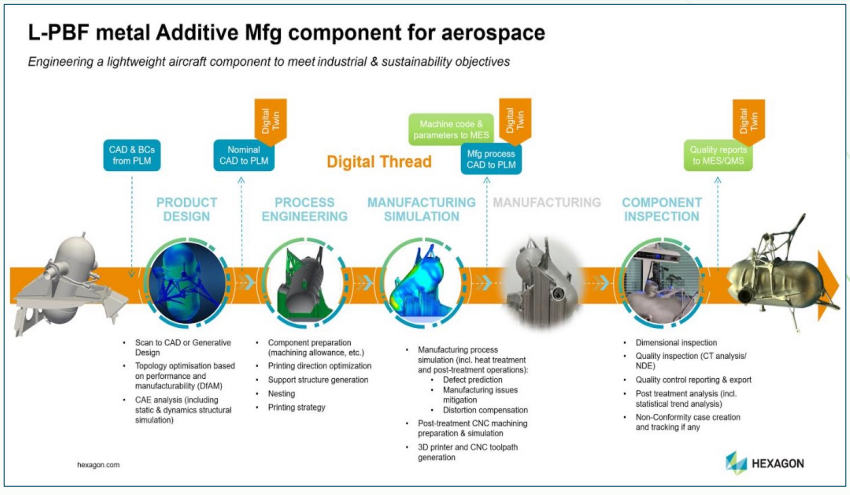
Use Case Spotlight

Digital Thread from Design to Manufacturing – Airbus A300 Air Separator Example

HEXAGON



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Use Case Spotlight

HEXAGON

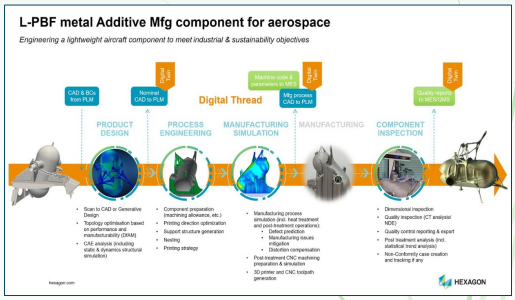
Digital Thread from Design to Manufacturing – Airbus A300 Air Separator Example

Use Case Objective

Demonstrate generation of iterative design loops and digital thread integration across design, simulation, and manufacturing processes using the Nexus platform.

Business Context

The solution illustrated Hexagon's data-centric approach to enabling agile, closed-loop workflows from design to part-ready production, incorporating additive manufacturing, simulation, and inspection capabilities.



Key Highlights:

- Robust digital thread execution spanning design, simulation, and inspection
- Open, tool-agnostic Nexus platform with topology optimization and additive workflow integration.
- "Smart Data Contract" enables agile feedback and real project validation
- Demonstrated real project integration with Airbus A300 Air Separator

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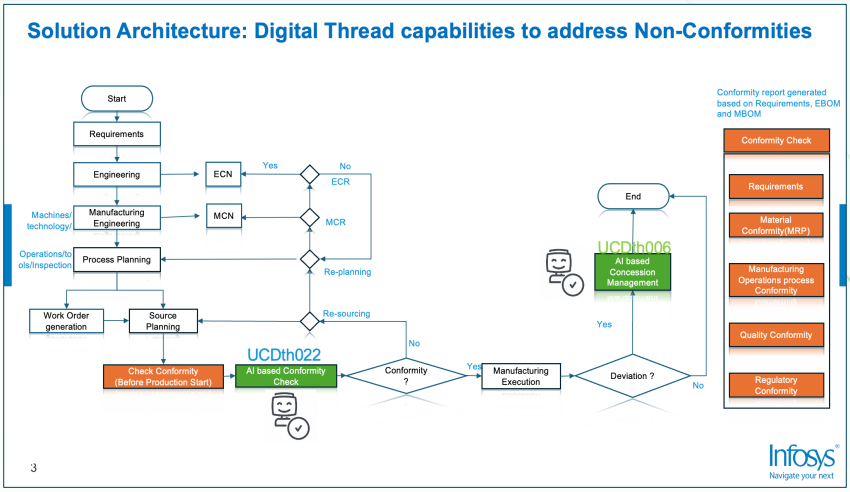
Use Case Spotlight

Infosys

Production & Support – AI-Enhanced PLM-MES Integration for Conformance Analysis



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Use Case Spotlight

Production & Support – AI-Enhanced PLM-MES Integration for Conformance Analysis

Infosys

Use Case Objective

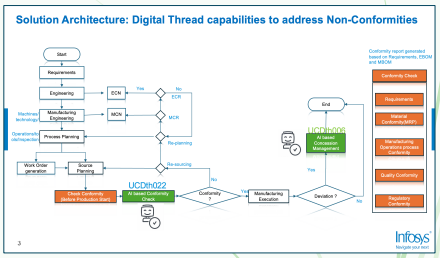
Demonstrate integration between PLM and MES systems within Dassault's 3DX platform, leveraging artificial intelligence to predict and prevent nonconformities during aerospace and defense manufacturing processes.

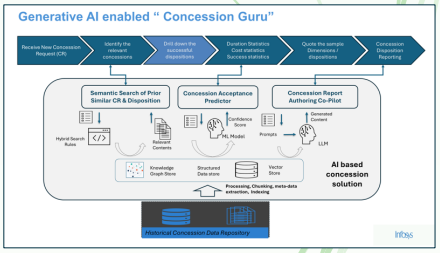
Business Context

The solution illustrates how AI-enabled digital threads can connect design and production, capturing and analyzing manufacturing data such as hole drill compliance to improve quality, efficiency, and traceability.

Key Highlights

- Strong PLM-MES integration on the 3DX platform with adaptable manufacturing workflows.
- AI-assisted quality monitoring and nonconformance prediction
- Integrated data capture and visualization across Enovia, Delmia, and Aprisio environments.





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Use Case Spotlight

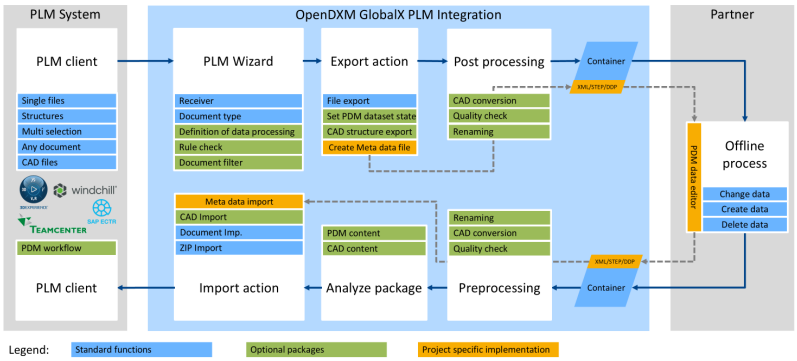
End-to-End Data Exchange and Collaboration through OpenDXM GlobalX

PROSTEP integrate the future

OpenDXM GlobalX PLM Integration

PROSTEP

Roundtrip process workflow for automating collaboration with external partners



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Use Case Spotlight

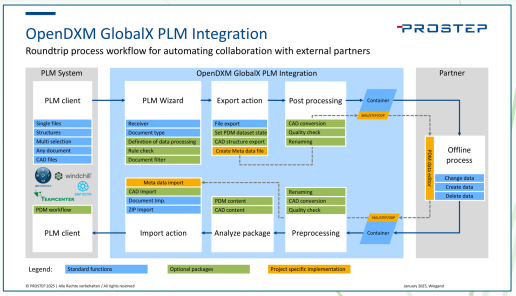
End-to-End Data Exchange and Collaboration through OpenDXM GlobalX

Use Case Objective

Demonstrate a complete end-to-end process using OpenDXM GlobalX, focused on native CAD export, transfer, import, with validation and traceability along the process.

Business Context

The solution highlighted secure, automated, and traceable data exchange between Teamcenter, 3DEXPERINCE, Windchill, and other PLM systems addressing interoperability and digital thread continuity across extended enterprises and supply chains.



Key Highlights

- Broad CAD/PLM compatibility supporting CAD export, transformation, and multiple formats
- Mature, proven platform with 30+ years of use, with over 500,000 active users
- Robust governance and collaboration via logging, traceability, and API-enabled integration

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Use Case Demonstrations

Evaluation dimensions and rating scale

Evaluation Dimensions

Use Case Goal
The intended outcomes and business value

Use Case Actions
The standard sequence of actions and their corresponding outcomes

Robustness
The ability of a system or solution to consistently perform well under various conditions

Ease of Use
The simplicity and intuitiveness of the system or solution

Adaptability
The ability to adjust in response to changing requirements, environments, or user needs

Rating Scale

0-Not shown

1-Minimally meets requirement

2-Mostly meets requirement

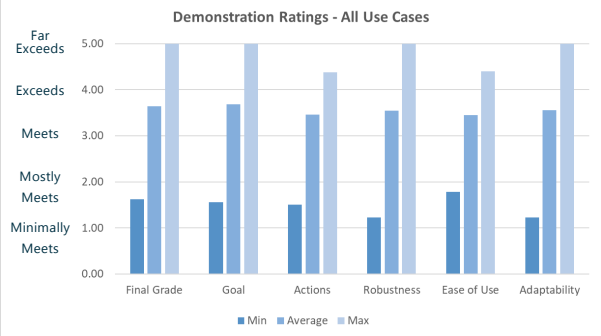
3-Meets requirement

4-Exceeds requirement

5-Far exceeds requirement

Use Case Demonstrations

Results – All use cases



- The demonstration ratings showed an overall positive outcome
- Average scores above 3.0, indicate that most use case demonstrations met or exceeded expectations in all evaluation categories
- Minimum scores between 1.0 and 2.0 suggests that a few demonstrations fell short of expectations.
- Most solution demonstrations were viewed as mature and strategically aligned
- Some solution demonstrations prompted concerns regarding their practical readiness and quality of execution

Use Case Demonstrations

Summary assessment of value (1 of 2)*

- Evaluator ratings
  - Overall, demonstrations rated as exceeding requirements
  - Individual provider demonstrations rated from meets to far exceeds
- Participants emphasized that
  - The collective learning experience and cross-industry exposure were invaluable,
  - Providing insights that could only be gained through a collaborative benchmark of this kind
- The sessions fostered a clearer understanding of where the industry stands today revealing both technical progress and conceptual divergence

* - Twelve senior domain experts from AD PAG member companies served as demonstration evaluators

Use Case Demonstrations

Summary assessment of value (2 of 2)

- Across all sessions, the collective experience offered exceptional educational value and industry insight
  - Evaluators described the demonstrations as “impressive” and “convincing,” though not all were at the same level of maturity or completeness
- While no single provider offered a complete Dtw-Dth platform, the collective demonstrations
  - Provided critical comparative insights
  - Revealed emerging best practices
  - Reaffirmed the collaborative benchmark’s value as a unique industry learning experience

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Conclusions

Key findings and dominant themes (1 of 3)

- Divergent strategies and uneven maturity
  - Two dominant strategic approaches have emerged
    - Focused Solutions – These providers offer deep, mature capabilities in a specific domain (e.g., simulation-led design, technical publications, or metrology)
    - General Solutions – These providers focus on the broader challenge of connecting disparate enterprise systems (PLM, ALM, MES, ERP) to create a cohesive data thread
  - This divergence results in a market where overall maturity is inconsistent
    - While individual solutions are technologically strong, no single provider demonstrated mastery across all benchmarked use cases
    - The industry's ability to create a truly seamless, end-to-end Dth is still evolving
- Architectural evolution from connectors to digital fabric or virtual-data-landscape
  - Move from point-to-point integrations towards more sophisticated architectural patterns
  - Concept of a federated digital fabric or digital backbone was a notable innovation

Conclusions

Key findings and dominant themes (2 of 3)

- Role of the major PLM platform solutions
  - Foundational but evolving within the broader Dth and Dtw ecosystem
  - Continues to serve as the authoritative source for 'as-designed' product data and the backbone for configuration and change management
  - Its position as the central program hub is increasingly being challenged and redefined by more open, federated, and data-centric architectures
- Pragmatic integration of AI
  - AI and ML have transitioned from conceptual ideas to practical enablers for advanced Dtw-Dth functionalities. Applications are concrete and focused on delivering specific business value
    - Predictive analytics and mode recalibration
    - Operational efficiency
    - Data quality management

Conclusions

Key findings and dominant themes (3 of 3)

- Critical prerequisites for success
  - Integrated multi-domain models
    - The ability to connect models from various domains (e.g., design, cost, supply chain, physics-based simulation) is essential for holistic analysis
  - PLM-MES integration
    - A seamless, bidirectional link between the PLM system ('as-designed/as-architected') and the MES ('as-manufactured/as-built') is fundamental
  - Open standards and interoperability
    - A reliance on open, neutral standards (e.g., STEP, JT, OpenUSD) is crucial for avoiding vendor lock-in and ensuring long-term data exchangeability and collaboration across the ecosystem
  - Robust data governance and archival
    - For industries like A&D, a strategy for archiving and accessing data for decades is a non-negotiable requirement

Conclusions

Persistent challenges and industry gaps

- Legacy System Integration
  - The rip-and-replace approach is not feasible
  - Integrating with deeply entrenched legacy systems remains a primary technical and financial barrier
- Long-Term Maintainability
  - The total cost of ownership is a major concern
  - The long-term effort required to maintain a complex web of connectors, adapters, and data models as underlying systems evolve is substantial and must be planned for
- Organizational Readiness
  - The technology is often more mature than the organization's ability to adopt it
  - A lack of clear vision, robust data governance, and effective Organizational Change Management (OCM) are significant impediments to realizing ROI
  - The A&D industrial community's readiness, while growing, is still in its early stages

Questions & Answers

What's on Your Mind?

To Learn More…

- Access A&D PLM Action Group resources at QR code below
  - Digital Twin-Digital Thread Solution Evaluation Benchmark Report of Findings (release in Nov 2025)
  - Digital Twin-Digital Thread Use Case Catalog (release in Nov 2025)
  - Model-Based Systems Engineering Research, report, Dec 2024
  - Digital Twin-Thread: Phase 4 – A&D Industry Digital Twin/ Thread Standards, position paper, Nov 2023
  - Digital Thread Collaborative Research, report, Aug 2023
  - Digital Twin-Thread: Phase 3 – Business Architecture Frameworks/Methodologies, position paper, Feb 2023
  - Digital Twin-Thread: Phase 2 – Problem, Objectives, Proposed Definitions, position paper, Jul 2022
- Access CIMdata resources at www.CIMdata.com
  - Promise and Reality of the Digital Thread - Results of Industry Research, webinar, Mar 2023
  - Multi-view BOM Value Potential, webinar, Apr 2022
  - The Digital Thread is Really a Web, with the Engineering BoM at Its Center, webinar, Sep 2021
- Contact for further discussion

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Thank You

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